AIR POLLUTION

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Introduction

By air pollution we mean the presence, in the air, of one or more substances that alter the composition and equilibrium of the atmosphere, causing harmful effects for humans, animals, plants and for the environment. In order to protect our Planet and its inhabitants we should not pollute the air. By adopting small daily actions, like switching off the lights when they are no longer required, using the car only if it is necessary, recycling waste, and by not exaggerating when heating or cooling environments where we live, we can avoid releasing into the atmosphere those gases that are responsible for pollution, that provoke acid rain, ozone depletion, and the greenhouse effect. How important a small gesture can be!

What is it

Air pollution sources

Air pollution takes place when chemicals contaminate the atmosphere affecting its structure and composition and producing significant harmful effects on human health, animals, vegetation and environmental quality.

Air pollutants can be classified according to their origin:

- anthropogenic (man-made) sources, which are the result of various human activities;
- natural sources such as fire particles, volcanic eruptions and degradation of organic matter.

Contaminants can also be classified as:

- primary pollutants, such as sulphur dioxide or nitrogen monoxide, which are directly emitted into the atmosphere from its sources;
- secondary pollutants, as ozone, which are formed as a result of chemical reactions in the atmosphere.

Anthropogenic pollution is caused by major stationary point sources as industries, incinerators and thermoelectric plants, minor stationary point sources as domestic heating systems, and by mobile point sources such as vehicular traffic.

Consequences of air pollution

Some pollutants, if they are present in excessive quantities, can produce chemical and physical alterations of the air, hampering its capacity to “work” correctly and guarantee our survival functions. Men’s activity usually originates pollutants (anthropogenic origin), although in some cases natural sources contribute significantly. Most of human-origin air pollution derives either from fossil fuels (their combustion is necessary to produce energy) or from industrial chemical processes. The environmental impact of air pollutants is variable: some compounds mainly act at local level, where they are produced and distributed, while others affect entire regions.

Some others have an impact on the whole planet. In fact, some atmospheric agents have a short life (a few hours or a few days) and after that they fall on the ground, while other pollutants keep active for long periods and can spread on a wider area. This type of pollutants can have an influence on environmental conditions at a continental, sometimes even planetary level, with a negative impact on human health, even in places that are far away from the source of pollution. In most cases, the type and quantity of pollutants emitted into the atmosphere depend on the nature of the energy sources that are used (see the corresponding section on natural resources) and on the raw materials that men use during production processes.

Air monitoring

To shape national development on the principle of environmental sustainability it's compulsory to refer to a comprehensive environment status report regarding specific geographical areas within each national district in order to define and implement a set of measures (which can be defined as "environmental policies").

At a later stage, the causes of environmental decay should be identified and a concrete set of measures should be pushed forward to stimulate environmental recovery and limit or abolish pollution sources. Monitoring atmospheric composition in a set area requires a thorough, long-term analysis carried out by an integrated air quality monitoring network formed by a number of measurement stations on this given area producing continuous results on pollutants found in the lower atmosphere. Traditional measurement techniques are based on physical, chemical and microbiological analyses indicating pollutant concentration and type. Air quality controls allow to observe atmospheric pollutant concentration and verify if legally-binding air quality limits are observed. Limit values (or guideline values) set for individual pollutants are measured according to national criteria. In every state these limits are always determined by concerns over environmental safeguard and human health protection. Only a small portion of atmospheric pollutants are monitored as only in these cases high-resolution measurement techniques are sufficiently accurate to allow ongoing monitoring. This type of monitoring allows anyhow an accurate estimate of air pollutant levels.

Biomonitoring is a new air quality evaluation technique, enforced in the past few years, which is carried out alongside traditional measurement. Biomonitoring techniques supply information on the extent of pollution evaluating the morphological or physiological response of living organisms – defined as biological monitors (or biomonitors) – to pollutant concentration.

Italian Legislation

Law N. 615 of July 13, 1966, "Measures against Environmental Pollution" is the first Italian systematic law on environmental pollution and defines fresh air as a public good that needs to be protected through restrictions. The latter was replaced by Decree N. 203 of May 24, 1988 of the President of the Republic (DPR) meeting four European guidelines on air quality and pollution.

The subsequent 203/88 Presidential Decree laid the real foundation for Italian legislation until the implementation in 1999 of the European Framework Directive on "Ambient Air Quality Monitoring

and Management". This D.P.R. introduces the principle of environmental preservation and human health safeguard, which was lacking in previous legislation. Moreover, it clearly defines the characteristics of environmental pollution as "every change to the structure or composition of the atmosphere caused by the presence of one or more substances in a quantity able to affect normal environmental conditions and air quality; which can pose a direct or indirect risk to human health; which can jeopardize recreational activities and other legitimate activities within this given environment; which negatively affect biological resources, ecosystems, public and private goods". As it also sets air quality limit values and guideline values and adopts the Anglo-saxon principle on the use of the best available technology (BAT) to prevent pollution.

The 96/62/CE European Directive issued in 1996 aims to create a common strategy to evaluate and manage air quality and define air quality standards to prevent or reduce the negative impact of pollutants on human health and the environment. The latter is a Framework Directive as it governs general and common policies for all Member States on air monitoring and management. Several subsequent 'daughter' directives were also adopted establishing air quality limit values and standard measurement criteria for specific pollutants. In Italy, Legislative Decree N. 351 "Implementation of the 96/62/CE Directive on Ambient Air Quality and Environment Monitoring and Management" passed August 4, 1999 transposed this Framework Directive. Legislative Decree 351/99 allocates responsibilities between the State and the Regions. Regions must implement air quality monitoring, action plans (in areas exceeding air quality standards) and protection programmes (in areas with very low levels of pollution), whilst the State must establish limit values and quality goals introducing an integrated strategy within national territory. Several other laws comply with 96/62/CE daughter directives, as:

- Ministerial Decree N. 60 of April 2, 2002 of the Ministry for the Environment and Protection of the Land, implementing the first daughter directive which sets limit values for NOx, SO2, Pb and PM10; and implementing the second daughter directive which relates to benzene and carbon monoxide;
- Ministerial Decree N. 183 of May 21, 2004 implementing the third daughter directive on ozone levels;
- Ministerial Decree N. 152 of August 3, 2007 implementing the fourth daughter directive which targets a list of pollutants posing a risk to human health (as cadmium, mercury, nickel, and polycyclic aromatic hydrocarbons).

Finally, Legislative Decree N. 155 of August 13, 2010 enforces "Directive 2008/50/CE on Ambient Air Quality and Cleaner Air for Europe". This Directive revises and combines separate existing pieces of legislation and sets a common legislative framework on ambient air quality monitoring and management.

Pollutants and their effects

Photochemical pollution

The “photochemical smog” is a typical form of pollution of all the main urban and industrial areas of the world. It occurs in or near areas with a high traffic density, in the presence of specific climatic conditions (no wind or weak winds, high temperatures, etc.), that cause the concentration of polluting gases to increase and prevent them from dispersing. In these areas, the concentrations of some gases (tropospheric ozone, carbon monoxide, particulate, VOC, nitrogen oxides, etc.) very often exceed the threshold values, above which there are risks for human health, farming and natural vegetation.

Atmospheric dust

Atmospheric dust consists of a mixture of solid and liquid particles suspened in the atmosphere varying in composition, source and size. Atmospheric dust particles can be removed out of the atmosphere by dry and wet deposition and fall back on soil, vegetation or watercourses. Atmospheric dust particles can be classified according to their diameter (measured in micrometers or µm. 1000 micrometers equivalent to 1 millimeter) ranging from 0,005 to 100 µm. Within this interval atmospheric particles are classified as:

- primary particles – diameter ranging from 2,5 to 30 µm;
- secondary particles – diameter lower than 2,5 µm.

Primary particles form from combustion, soil erosion and disintegration. Pollen and spores figure in this category. Secondary particles are generated by vehicular traffic, industrial activities and thermoelectrical implants. Atmospheric dust particles with a diameter of less than 10 µm and 2,5 µm draw special attention and are defined PM10 and PM2,5 (PM= Particular Matter), respectively. PM2,5 particles are a subset of PM10 and count for 60% of its weight. PM10 is an inhalable particle as it can travel deep into the breathing apparatus to the larynx; and it’s also breathable as it can settle in the pulmonary alveoli. These dust particles raise serious health concerns as they have been linked to a number of breathing and cardiovascular diseases. Sources of dust particles can be natural (volcanic eruption, sea aerosols, spores, pollen, soil erosion, …) or man-made (vehicular traffic, industrial emissions and combustion processes).

Benzene

Benzene is a molecule composed of 6 carbon atoms joined in a ring and 6 hydrogen atoms. Benzene is classified as a polycyclic aromatic hydrocarbon (PAH). It’s a liquid substance, but at high temperatures it has a rapid volatilization process passing from a liquid phase into a gas phase. Benzene is either natural and can, for example, be generated by volcanic eruptions or is man-made. In urban centres benzene is almost exclusively generated by human activities as vehicular traffic, oil-refining and fuel distribution. Its major sources are, in particular, exhaust emissions and to a

lesser extent evaporation losses during the handling, distribution and storage of petrol. Tobacco smoke is an important source of benzene in indoor air, and median benzene levels have been found to be 35% higher in the homes of smokers than in non-smoking households. Benzene absorption occurs by inhalation, dermal route and ingestion and can cause chronic and/or acute effects. The most reported effect of chronic benzene exposure is potential carcinogenicity.

Acid deposition

The term acid deposition refers to the process by which acid particles, gases and precipitation fall from the atmosphere. If this acid deposition takes place in the form of precipitation (rain, snow, fog, dew, etc.) we speak of wet deposition, otherwise the phenomenon is dry deposition. The term 'acid rain' can also be used to describe these phenomena, by which, however, only the phenomenon of wet acid deposition is often referred to.

The substances that give rise to acid deposition are sulphur oxides (SOx) and nitrogen oxides NOx), whose origin in the atmosphere can be either anthropogenic or natural. If these pollutants do not come into contact with atmospheric water, they are deposited on the ground, quickly giving rise to acidic compounds. If, on the other hand, these pollutants come into contact with atmospheric water, then acidic compounds are formed prior to ground deposition. Sulphur oxides and nitrogen oxides respectively form sulphuric acid and nitric acid, which lower the normal pH of water from 5.5 to values between 2 and 5, acidifying precipitation. Acid deposition changes the acidity of lake and river water (making it impossible for fish and other aquatic organisms to live) and that of soil (altering the availability of nutrients, thus reducing its fertility and productivity). Acid deposition can also directly damage vegetation (e.g. by dissolving the protective waxes of leaves, they make them more vulnerable to pests), buildings and monuments. The health of humans and animals may be damaged if they eat food from acidified water or soil.

The problem of acid rain can be solved by reducing atmospheric emissions of nitrogen oxides and sulphur oxides. To reduce these emissions, we need to limit the use of sulphur-rich fossil fuels (such as coal) and reduce the use of cars and heavy traffic in our cities. There are various technologies that can greatly reduce the sulphur content in fossil fuel feedstocks (coal reclamation, desulphurisation systems, and others). In addition, the chimneys of power and industrial plants have been equipped with filters that trap sulphur compounds in the exhaust fumes, preventing their dispersion into the atmosphere. On the other hand, emissions of nitrogen oxides, which are mainly emitted by passenger cars, can be reduced by adopting catalytic converters. In particular, it is important for a country's car fleet (i.e. the cars that are used by its inhabitants) to be recent, as the latest generation of cars are fitted with devices that enable nitrogen oxide emissions to be limited much more effectively than in the past.

It takes many years for an ecosystem damaged by acid rain, such as a lake or river or a forest, to return to its original state of equilibrium. Man can intervene to accelerate this process with some targeted action: for example, by adding lime to acidified lakes or rivers to bring their pH back to neutrality (calcification). However, such techniques are expensive and their effects have a limited

duration. In such cases, it is certainly better to prevent the adverse effect than to intervene to cure and mitigate the damage caused.

Ozone

The Ozone Hole. Ozone (O_3) is a gas found in in high levels in the stratosphere, in a region also known as the ozone layer, between 15,000 and 40,000 metres above the surface where it plays an important role screening the sun's ultraviolet radiations which are harmful for living organisms. In the past years stratospheric ozone levels have declined due to the effect of anthropogenic substances, as chlorofluorocarbons (CFCs), methyl bromide, halon gases and methyl chloroform. Once these gases reach the stratosphere they emit chlorine and bromine, which affect ozone formation.

Since the 1980s slow and gradual depletion of the stratospheric ozone has occurred, especially over Antarctica. Size and rapidity of the ozone hole formation alarmed the scientific community: in 1987 was issued the Montreal Protocol, the first international treaty ratifying the reduction of CFCs use. So far the Montreal Protocol has been adopted by over 190 states (link to sustainability for more information on this subject): nowadays global use of CFCs is lower but many years need to pass before existing CFCs can be eliminated from the atmosphere.

The major direct consequence of the hole in the ozone layer is an increased amount of ultraviolet radiations (UV – frequency from 100 to 400 nm) reaching the Earth's surface.

These radiations cause:

- increased risk for skin tumours and eye diseases;
- decreased immune system functions in men and animals;
- photosynthesis reduction and DNA damage in plants with a significant negative impact on agriculture;
- lower levels of marine phytoplankton production causing serious damage to the marine chain in aquatic ecosystems.

Ozone in the Lower Atmosphere. Ozone pollution refers to higher ozone concentration in the troposphere, the only atmospheric layer which can support life, and which shouldn't be mistaken for the ozone hole. Tropospheric ozone is formed by the interaction of sun radiations and primary pollutants, especially nitrogen dioxide. Ozone is harmful for men and the environment as it's a powerful oxidant which can cause negative effects when reaching high concentration in the air, after long-term exposure and high concentration in ambient air breathed by humans.

Improving air quality

An unstable balance

We have seen that atmospheric pollution derives from a series of substances that are produced by one or more "sources" (industries, cars and others). Luckily, after a more or less long time spent in

the atmosphere, nature can “remove” a certain amount of it. For instance, the carbon dioxide produced by the combustion of fossil fuels and by the breathing of animal and vegetal living organisms is absorbed not only by the vegetation (through the photosynthesis), but is also largely counteracted by seawater, that can fix it through the phytoplankton and stabilise it in carbonated sedimentary rocks. The composition of the atmosphere is therefore in a state of dynamic balance, whose stability depends on the ability of these “self-depuration” processes to counteract or at least reduce the negative effects of man’s activities. The problem arises when the amounts of pollutants emitted in the atmosphere exceed its “self-depurating” ability, increase their concentrations in the air and reach limits that are harmful to man and to nature. In this case, the development model of man and of a country may be no longer “sustainable” in the long term.

Urban pollution

Most Italian cities are affected by urban pollution, which is a major problem. This is demonstrated by data from monitoring stations measuring pollutant concentration. Even in those cities and areas where these stations are lacking we can feel the air is polluted as we experience breathing difficulties or problems. Traffic is currently the main source of pollution in every city. Domestic heating emissions are another major pollution cause during winter.

Pollutants are formed from the combustion generated by automotive engines and heating systems. Among pollutants, particulate matter is the worst problem occurring in Italian cities. In fact, in most Italian cities, suspended particulate matter with diameter below 10 microns, termed PM10, is increasingly exceeding threshold limit values prescribed by law.

Public administrations are pushing forward curbing measures to reduce PM10 concentration as number plates and traffic restrictions and the creation of banned areas for the most polluting vehicles. These measures alone, though, are not going to abolish urban pollution as, usually, the latter aren’t adopted on a long-term period but are temporary enforcements as “car-free Sundays”.

A sensible reduction of urban pollution calls for structural changes, as the substitution of older, more polluting vehicles with newer and more ‘eco-friendly’ ones or substituting older domestic oil fired boilers with methane fired boilers as well as changing individual behavior. Here is a set of best pratices that can help reduce pollution in our cities:

- drive at moderate speed: as this helps producing less pollutants and save energy as you’ll be using less petrol;
- park without interrupting traffic movement;
- wherever possible turn off the engine when stationing or queing for a long time;
- check your car engine and exhausts on a regular basis;
- use public transport, go by bike or walk;
- if you need to use your car try travelling with more than one passenger or organise a carpooling;
- when you’re buying a new car choose among the most eco-friendly;

- join with other citizens to ask the local administration to build more cycle lanes, pedestrian areas and restricted traffic areas.

Actions to make a difference

What can you do to help reduce air pollution and contrast anthropogenic greenhouse gas concentration? International organisations, national governments and industries can contribute to curb pollutant emissions and "greenhouse gases" enacting specific environmental measures. In many countries excellent results have already been achieved and industries are paying increasing attention to effectively reduce pollutant emissions. We can all contribute acting responsibly and adopting best practices on a daily basis! Air quality depends from us all: if we all pay more attention to this issue every day we can contribute reducing pollutant emissions in the air: and we'll also be able to save money.

Eco-friendly. Travelling Using more public transport and less private vehicles is a great measure to reduce air pollution in cities. Using public transport (buses, trams, metro, trains), cycling and walking are the best ways to help saving the environment.

Cooling Down is better for the Earth. During winter, if the temperature in classrooms was lowered by only half degree Celsius in every school we could cut CO_2 emissions by 7%. Moreover, insulating windows, rooftops and walls allows to reduce heating consumption and save energy. Regular routine maintenance for boilers and domestic heating systems as well as boiler emissions testing are crucial to reduce domestic heating system emissions. Switching to methane fired boilers, relying on solar panels and photovoltaic panels and general energy saving also contributes to the reduction of domestic heating emissions.

Save electricity! Remember to switch off lamps when you don't need artificial light: if you switch off a 60-watt lamp for 5 hours a day, over one year you can reduce CO_2 emissions averagely by 80 kilos. You should know, in fact, that 0,72 CO_2 kgs are released in the atmosphere to generate 1 kWh! Remember also to buy energy saving electrical appliances (as Class "A" fridges, washing machines, or dishwashers as stated by labels on each appliance).

Paper never gets old! Recycling paper can help reducing dangerous gas emissions. Producing paper requires energy and tree cutting to produce chemical products as binding agents, bleaching agents, and solvents producing atmospheric pollution.

Keywords: choose, diversify, recycle. Waste disposal produces a great quantity of dangerous gases emitted in the atmosphere. For example, each kilo of organic waste generates 0,31 kgs of methane, which is a dangerous greenhouse gas. We should choose products with recycled packaging. Diversifying and recycling waste means generating less dangerous greenhouse gases emitted in the atmosphere.

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